Toxicity of Paralytic Shellfish Poisoning (PSP) in the Geoduck Clam

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Introduction

Paralytic shellfish poisoning (PSP) has a long history of causing major problems for shellfish consumers all over the world. (Bricelj and Shumway, 1996; Jellet, 1993; Shumway, 1989; Shumway, 1990; Neal, 1967; Sribhibhadh, 1963). Public health becomes threatened because serious illness or death can occur when toxic shellfish are consumed. Industry also becomes threatened owing to the closure of shellfish harvesting grounds, depressed markets due to loss of consumer confidence in the shellfish products, and loss of income. At present, the most effective and powerful tools available to regulatory agencies, harvesters, producers, and sellers of shellfish products in the battle against PSP are monitoring programs. In most cases, these programs effectively accomplish the following:

- minimize the threat of PSP to consumers;
- prevent product recall and minimize economic losses;
- minimize waste and protect the resource; and
- minimize harvest disruption.

In the state of Washington, the geoduck clam (*Panope abrupta*) is a valuable economic resource, valued between $3–7 million dollars annually (Figure 1; J. Markert, Washington Department of Natural Resources, pers. comm.). Recently, new, large markets have developed domestically and overseas in Hong Kong, Japan, and Singapore, where consumers often pay $12/lb or more for whole live clams. However, geoducks have been found to filter and accumulate certain algae that produce PSP toxins naturally, therefore increasing the risk of PSP to consumers. Until very recently, PSP toxicity levels in geoducks were not considered a risk to public health for various reasons:

- The viscera, typically the area for toxin accumulation in many bivalves, were assumed to be discarded prior to consumption.
- Harvesting for geoducks occurred in "PSP-free" areas of southern Puget Sound.
- Low demand for geoduck meat resulted in little pressure to increase the number of harvestable tracts.

Now, there are new causes for concern for the Washington Department of Health (WDOH):

- The visceral ball is being consumed by some members of tribal and overseas communities, who use it in soup.
- The demand for geoduck meat has skyrocketed recently, resulting in new tribal and state commercial tracts being opened in historical PSP areas of central and northern Puget Sound.
- Toxic algal blooms are extending into the previously benign areas of southern Puget Sound, resulting in previously unseen PSP toxicity in geoducks in those locations.
- Many thousands of dollars worth of geoducks are not being harvested due to concerns about PSP toxicity.
- Unfortunately, no previous information exists regarding PSP toxicity in geoducks. Variability in toxicity and anatomical distribution of toxins are unknown. Without such information, it is difficult to assess the effectiveness of the current geoduck monitoring program in protecting public health.

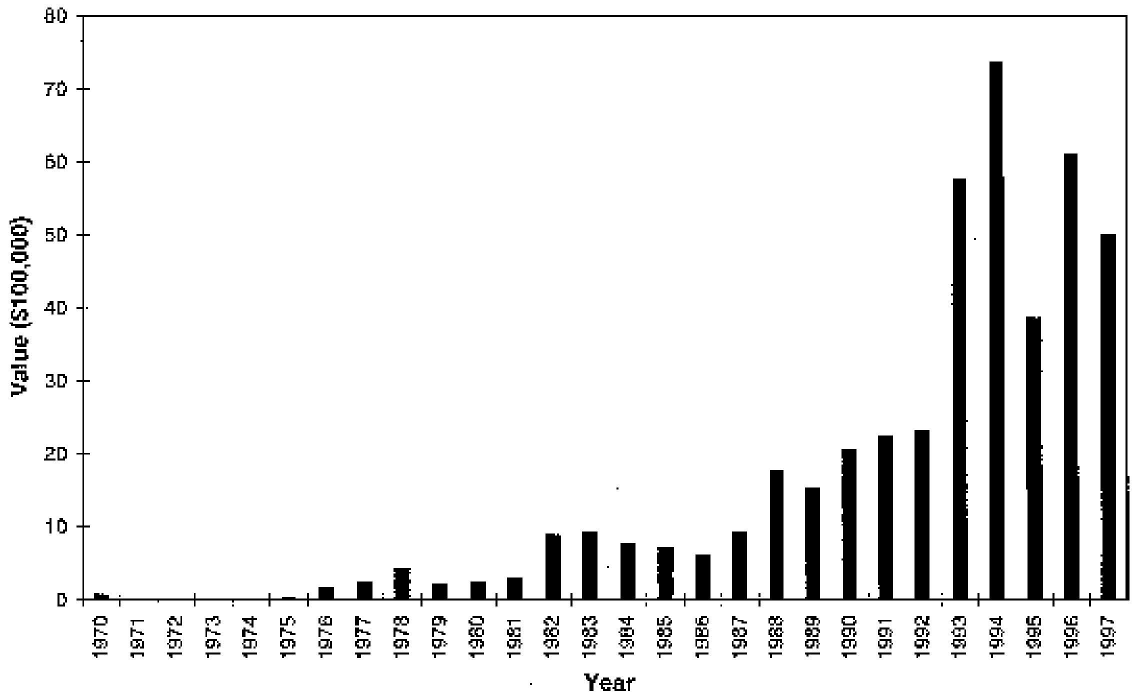

Figure 1. Annual revenue for the Washington State geoduck fishery.

Main Questions

The purpose of this study is to address the following questions:

- What is the variability in toxicity? How does toxin variability change among populations of geoducks, or among seasons?
- What is the anatomical distribution of PSP toxins?
- How should the current geoduck PSP monitoring program be modified to better protect public health?
- How do the mouse bioassay and the receptor binding assay compare in testing for PSP? Currently the mouse bioassay is the only approved method for PSP testing. The receptor-binding assay has advantages over the mouse bioassay in that it uses no live animals, is significantly less expensive, and is a high-capacity test (Doucette et al., 1997).

Methods

From June through October 1997, geoducks were collected from Quartermaster Harbor (QH), Puget Sound, by a dive team from the Puyallup Tribe. From August 1997 through January 1998, geoducks were collected near Agate Pass (AP), Puget Sound, by a dive team from the Washington Department of Natural Resources (WDNR). Within each tract, a shallow location (18 ft) and a deep location (50 ft) were selected, and all subsequent samples came from those locations. Biweekly, 10 geoducks were collected from each sampling location (20 total from each tract), along with data on substrate type, bottom temperature, whole wet weight, and shell length. Blue mussels (*Mytilus edulis*), which were also collected in Agate Pass from a lantern net suspended above the collection areas, were used as a sentinel species. After collection, geoducks were individually numbered and dissected into individual tissues: neck, mantle, visceral ball, and gill. Each tissue sample was analyzed separately for PSP toxins using the standard mouse bioassay (AOAC, 1984; Adams and Miescier, 1980; M. A. Kirkpatrick, WDOH, pers. comm.). The same results will be analyzed using the receptor-binding assay, and the results will be compared with the mouse bioassay results.

Results

Toxicity levels in geoducks from Quartermaster Harbor can be seen in Figure 2. In the deep location, variability in toxicity was low, with a pooled standard deviation (SD) of 17 g toxin, and did not change over the season. In the shallow location, variability was significantly higher, with a pooled SD of 148 g toxin, and was irregular and unpredictable throughout the study. Mean toxicity level was not increasing or decreasing, and was unpredictable as well.

Toxicity levels in geoducks from Agate Pass can be seen in Figures 3 and 4. Blue mussels do not appear to show any correlation with geoduck toxicity. Statistically, variability did not change over the season for either the deep or shallow locations, with pooled SDs of 115 g toxin and 271 g toxin, respectively. Harvest depth had an effect on variability 55% of the time. For example, there was a significant difference between the deep and shallow Agate Pass areas on August 19th, October 14th, October 28th, December 10th, December 23rd, and January 20th. In addition, harvest depth had an effect on mean toxicity level 45% of the time. For example, there was a significant difference between the deep and shallow Agate Pass areas on August 19th, September 2nd, October 7th, December 10th, and December 23rd. In summary, differences between the deep and shallow areas were not predictable in terms of mean toxin level or seasonal variability. This is in contrast to Quartermaster Harbor, where the deep and shallow areas differed significantly throughout the study period.

Overall, variability found in the shallow location of AP was approximately twice that found in QH. The variability found in the deep location of AP was approximately six times that found in QH. There was no correlation between geoduck weight and toxicity in either tract. Toxicities in each of the tissues can be seen in Figure 5, which shows that toxins appear to be isolated to the visceral ball.

Preliminary Conclusions and Implications

1. Currently, the WDOH uses a sample of three geoducks for PSP monitoring purposes. This does not appear to be sufficient, given the range of toxicities seen in the study areas. The WDOH may need to revise current sampling methods in order to better protect public health, to minimize product recall, and to minimize economic losses.

2. It may be necessary to issue a warning to consumers stating that the toxins are isolated to the visceral ball, and should be discarded prior to consumption since the market demand is for whole geoducks.

3. Overall, variability and mean toxin levels appeared to be lower in the deeper areas of a harvest tract. Perhaps harvest should be limited to certain depths during the PSP season.

4. Harvest tracts appear to behave differently in terms of mean toxin levels, seasonal highs and lows in toxicity, and seasonal variability. Each tract may have to be treated individually when sampling geoducks for PSP monitoring.

5. Currently, several monitoring programs around the world use mussels as an "early-warning species" for PSP toxicity in bivalves. Since no correlation between mussel and geoduck toxicity is apparent, blue mussels might not be effective as a sentinel species in monitoring for PSP in geoducks.

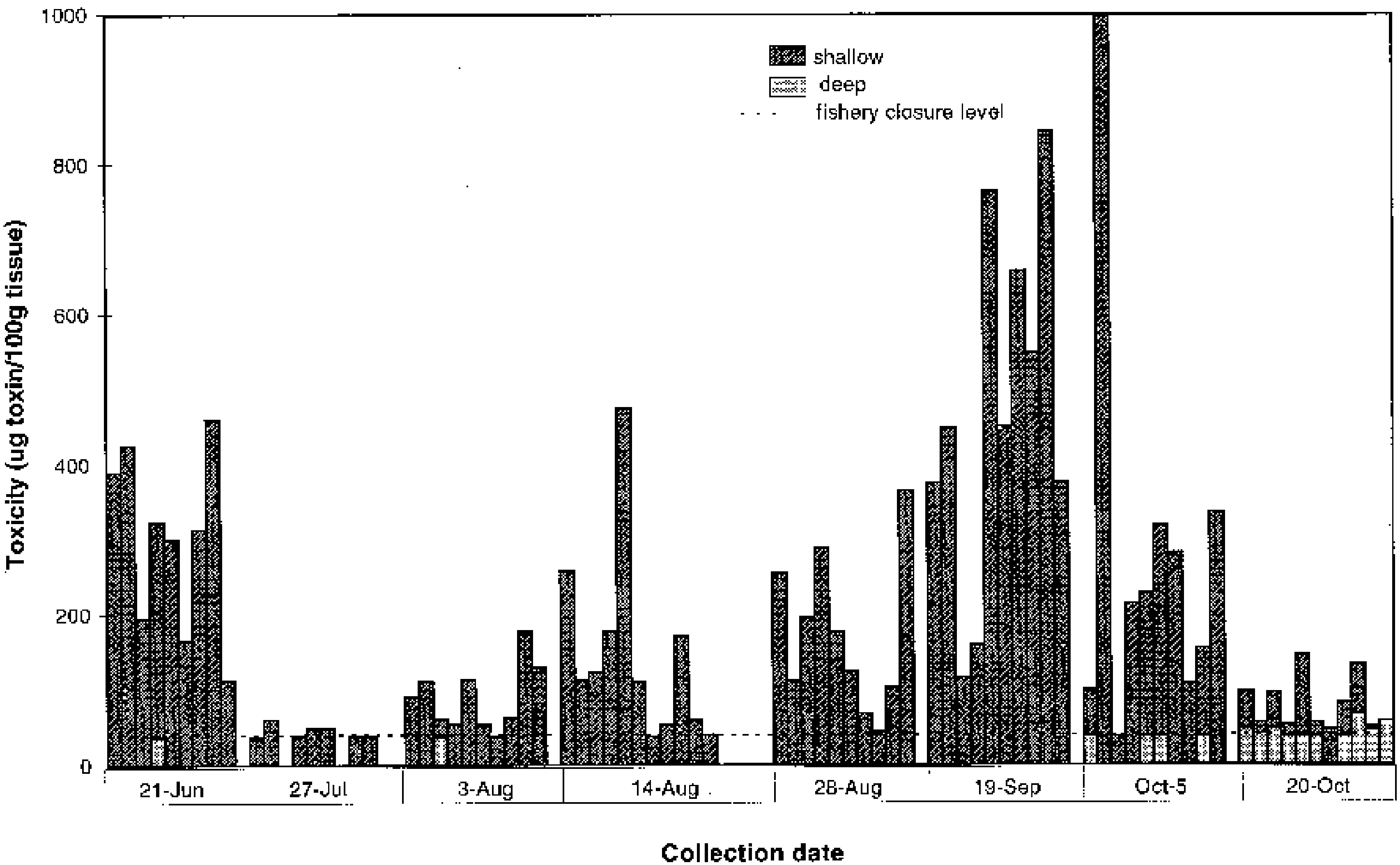

Figure 2. Toxicity levels in individual Quatermaster Harbor geoducks, June–October 1997.

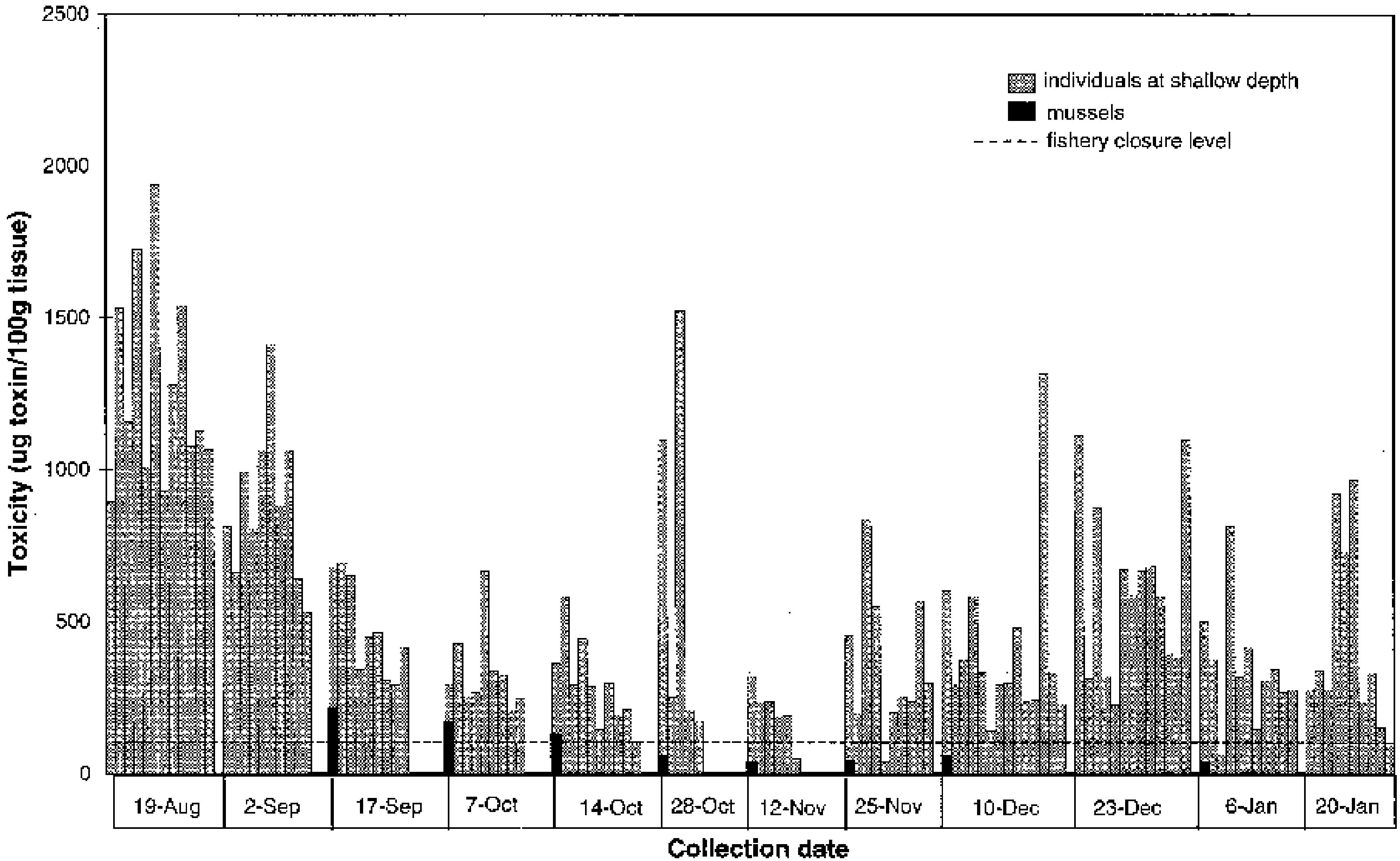

Figure 3. Toxicity levels in individual geoducks from the shallow area of Agate Pass, August 1997.

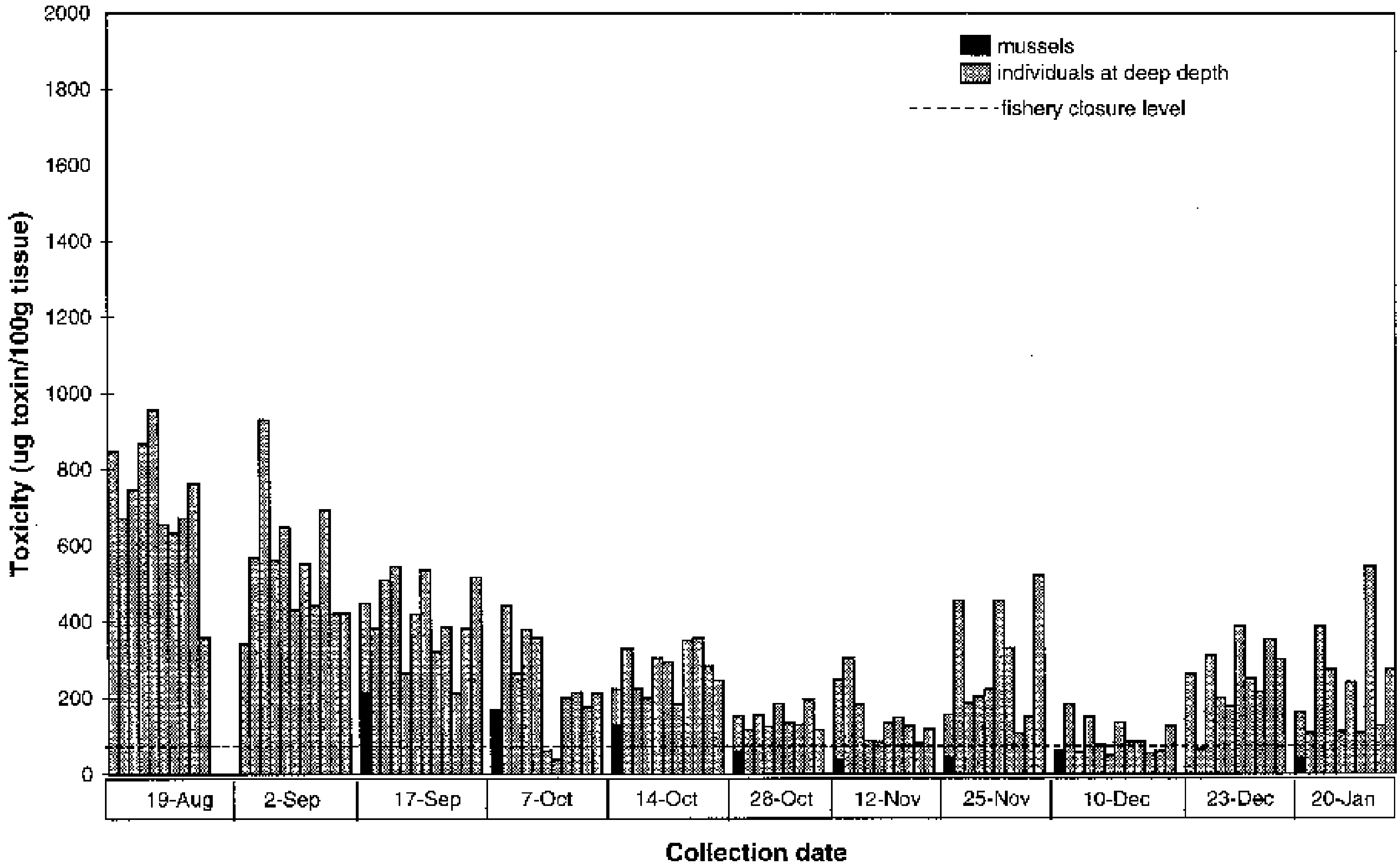

Figure 4. Toxicity levels in individual geoducks from the deep area of Agate Pass, August 1997

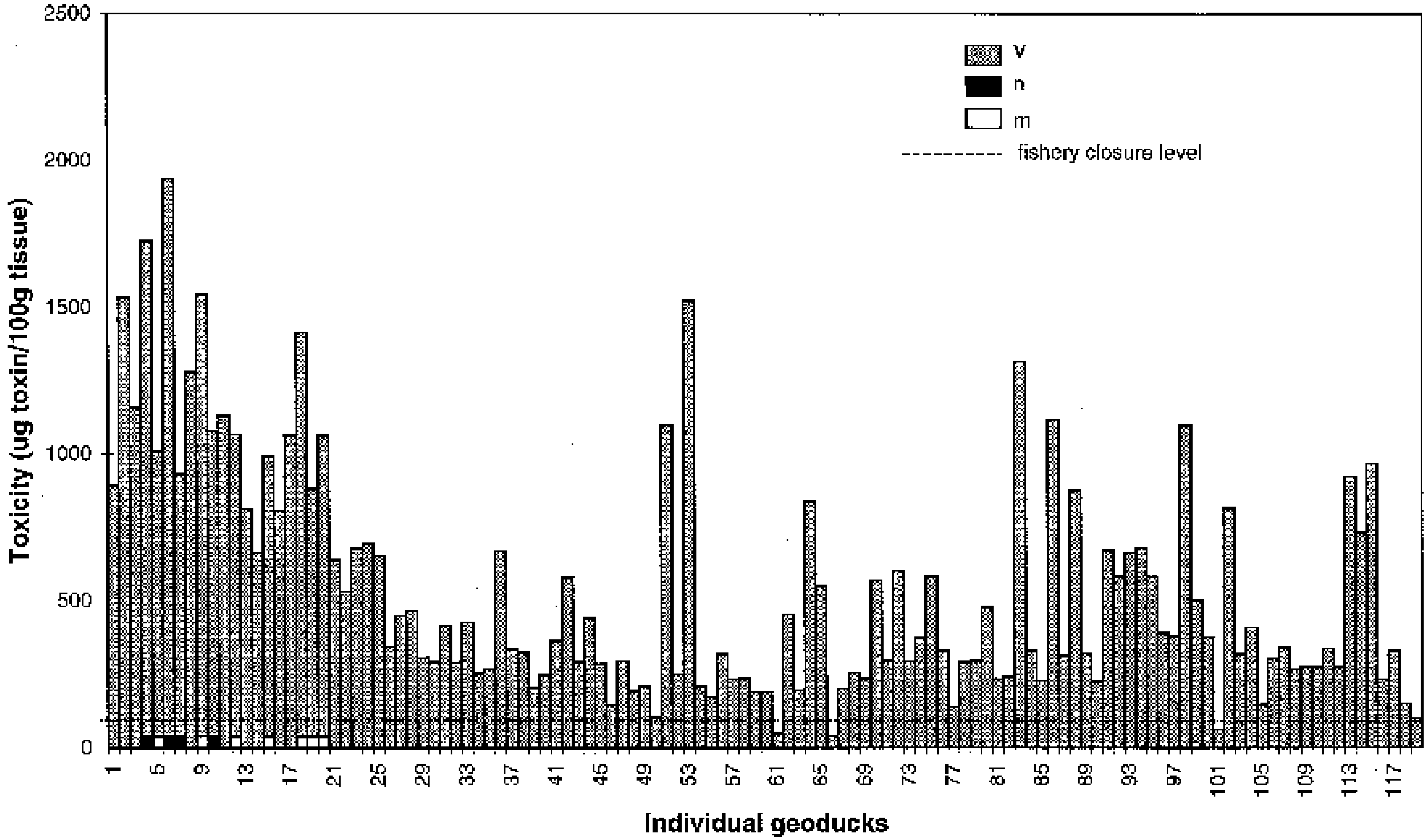

Figure 5. Toxicity levels in each of the dissected tissues: neck (n), mantle (m), and viscera (v). Data are from individual geoducks in the shallow Agate Pass collection area, August 1997–January 1998.

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